COMPRESSIVE STRENGTH OF RUBBERIZED-ULTRA HIGH PERFORMANCE CONCRETE WITH DIFFERENT ELEVATED TEMPERATURE

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Kemajuan teknologi menjadikan bahan konkrit membawa kepada pembangunan jenis komposit bersaiz baru yang dikenali sebagai Ultra High Performance Concrete (UHPC). UHPC adalah sejenis konkrit yang dikenali dengan kekuatan yang sangat tinggi dan ketahanannya. Bahan buangan dikenali sebagai bahan yang boleh menyebabkan masalah kepada alam sekitar. Bahan buangan boleh dikurangkan dengan memprosesnya dalam bahan binaan seperti UHPC. Bahan sisa yang digunakan dalam kajian ini adalah sisa tisu sampah (WCT). Objektif dalam kajian ini untuk menentukan kekuatan mampatan UHPC getah pada suhu tinggi yang berbeza seperti 100˚C, 150˚C dan 200˚C dan menentukan penurunan berat getah UHPC tertakluk kepada keadaan pra pemanasan. Tayar sampah buangan diubahsuai pada rawatan permukaan dengan menggunakan NaOH dengan tempoh 20, 40 dan 60 minit. Tayar serbuk sisa digunakan sebagai pengganti agregat kasar dalam 5% daripada jumlah berat keseluruhan agregat kasar dan akan dicampur bersama untuk membuat getah UHPC dengan peratusan 5% tetap WCT. Berdasarkan hasilnya, dapat disimpulkan bahawa UHPC getah dengan rawatan permukaan 60 minit atau getah UHPC-60 adalah yang terbaik dengan kekuatan dan penurunan berat dibandingkan dengan rawatan permukaan UHPC getah lain.

ABSTRACT

Advance in technology makes the concrete material led to the development of new type of cementitious composites which known as Ultra High Performance Concrete (UHPC). UHPC is a type of concrete known by its exceptionally high strength and durability. The waste materials were determined as material that can cause problem to the environment. The waste materials can be reduced by processing them in construction materials such as UHPC. The waste material used in this study was waste crumb tyre (WCT). The objective in this study to determine the compressive strength of rubberized UHPC at different elevated temperatures such as 100˚C, 150˚C and 200˚C and determine the weight loss of rubberized UHPC subjected to pre-heating condition. The waste crumb tyre were modified on surface treatment by using NaOH with duration of 20, 40 and 60 minutes. The waste crumb tyre were used as replacement for coarse aggregate in 5% of percentage from total weight of coarse aggregate and will be mixed together to make rubberized UHPC with fixed 5% percentage of WCT. Based on the result, it can be concluded that the rubberized UHPC with surface treatment 60 minutes or rubberized UHPC-60 is the best with strength and weight loss compared to other rubberized UHPC surface treatment.

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LIST OF SYMBOLS

˚C	Celcius
˚	Degree
kg/m^3	Kilogram per metre cube
kN	Kilo-Newton
MPa	Mega Pascal
µm	Micrometre
mm	Millimetre
N/mm^2	Newton per millimetre square
%	Percentage

LIST OF ABBREVIATIONS

Agg	Aggregate
OPC	Ordinary Portland cement
SF	Silica fume
NaOH	Sodium hydroxide
SP	Superplasticizer
UHPC	Ultra-High -Performance Concrete

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Advance in the technology make the concrete materials led to the development of new type of cementitious composites which known as Ultra-High Performance Concrete (UHPC). UHPC is a type of concrete known by its exceptionally high strength and durability. It was developed in Europe in the 1980s for specialized applications that need superior strength and corrosion resistance. In 2000, UHPC has become commercially available in the United States that lead to the series of research project to demonstrate the capabilities of the material as stated by (Graybeal, 2011). The properties of high strength and durability UHPC make it an optimal model for use in developing new solutions for highway infrastructure deterioration, repair and replacement. Besides that, UHPC also used as marine anchors, piers and seismic structure. UHPC also has less water-cement ratio which is 0.25 than mechanical properties of UHPC include compressive strength greater than 150 MPa and the sustained post-cracking tensile strength greater than 5 MPa as mentioned by (Graybeal, 2011). UHPC also has been used in a variety of the applications such as precast concrete piles, seismic retrofit of substandard bridge substructures and security and blast mitigation applications. The elements or materials contain for making UHPC such as Ordinary Portland Cement (OPC), sand, ground quartz, silica fume and water. However, the ground quartz as the ingredient for make this UHPC is expensive affected to the cost production compare with other materials. The new solution has been determined to replace the ground quartz that act as the aggregate with use of recycled waste tire or waste crumb tire to reduce the cost production. This material will replace the ground quartz as the aggregate and places for make UHPC.

In recent decades, the worldwide growth on automobile industry and increasing the use of cars as the main transport have been accelerates boosted on the production of tire. This has produced huge stockpiles of used tires. Besides that, more than 270 million scrap-tires are produced in United States each year (Rubber Manufacturers' Association, 2000). On the other hand, the rubber tires also used in making fuel for cement kiln, and feedstock for making carbon black. The involvement of high capital investment in it by using tires as a fuel is not economically attractive. The stockpiles are dangerous not only effect the potential environment threat but also from fire hazards and contribute breeding grounds for rats, mosquitoes and bedbugs. In addition, over 300 million tires reach their service life every year in European Union alone and become waste. (Sofi, 2017) stated that the waste tires disposal contributes to the decreasing of biodiversity because tires contain toxic and soluble components. The waste tires disposal also can cause the temperature to be high when the tires started to burn down and generates toxic fumes (Sofi, 2017).

1.2 Problem Statement

In making Ultra-High Performance Concrete (UHPC), the materials used contain such as ground quartz, Ordinary Portland Cement (OPC), sand, silica fume and water. However, the ground quartz is expensive material compared with others material thus it would increase the cost of production making UHPC. Next, in order to decrease or reduce the cost production for making UHPC, an alternative waste material can be used to replace the ground quartz which is replace it with recycle waste tire. Recently, the quantity of recycle waste tire become increases because of the production of vehicles from day to day increases. Besides that, the use of recycled waste tire provides low cost in production of UHPC. The recycled waste tire safe the environment impact. In this research study is crumb rubber from waste of by-products namely as waste crumb tire (WCT). As a comparison with previous research, UHPC was introduced and the success in the formation of superplasticizers has make the development for the new concrete family of UHPC, which has reach the compressive strength that was earlier possible only with steel as mentioned by (Randl, et al., 2014).

However, the waste crumb rubber has some problems when used as aggregate replacement. Several researchers found that, the size, proportions and surface texture of rubber particles able affect compressive strength of mixtures (Thomas & Gupta, 2015). Furthermore, the concrete mixtures that been added with crumb rubber aggregates lower

compressive and splitting tensile strength than regular Ordinary Portland cement concrete (Thomas & Gupta, 2015). The crumb rubber has ability to absorb a large amount of energy under compressive and tensile loads. Thus, the previous research has determined when crumb rubber has rough surface or given a pre-treatment, the crumb rubber becomes better and improved bonding will develop with the surrounding that make the compressive strength to be higher.

1.3 Objective of Study

i. To determine the compressive strength of rubberized UHPC at different elevated temperatures.
ii. To determine the weight loss of rubberized UHPC subjected to pre-heating condition

1.4 Scope of Study

Stage 1: Preparation on The Surface Treatment of WCT

The concrete mixed with waste crumb tyre has good toughness and strength rather than traditional concrete. Besides that, it has better heat and sound insulation properties. Despite, the waste crumb tire has poor interface compatibility with inorganic materials. Moreover, the surface for WCT was hydrophobic and cement paste was hydrophilic material thus the bonding between WCT and cement paste was poor. Several researches have been done to enhance the performance through the surface treatment of WCT as mentioned by (He, et al., 2016). Before use the WCT with the concrete mixed, it will be washed by using acetone. Then, the waste crumb tire (WCT) will be immersed into sodium hydroxide solution, NaOH solution at different duration. The WCT will immersed into the solution about 0, 20, 40 and 60 minutes to strengthen the compressive strength for WCT. The main role of NaOH is to discard the tyre rubber soaked formulation additives and saturated in NaOH solution for 24 hours will not change the hydrophobic nature of rubber mentioned by (He, et al., 2016). After the WCT has been dissolved into NaOH solution, it will be washed again with the distilled water. As stated by (Eldin & Senouchi, 1993) soaked and washed crumb rubber with water used to remove

REFERENCES

Alsalman, A., Dang, C. & Micah Hale, W., 2017. Development of ultra-high performance concrete with locally available materials. *Construction and Building Materials,* Volume 133, pp. 135-145.

Mohammed, B. & Adamu, M., 2018. Mechanical performance of roller compacted concrete pavement containing crumb rubber and nano silica. *Construction and Building Materials,* Volume 159, pp. 234-251.

Motahari Karein, S. et al., 2017. A new approach for application of silica fume in concrete: Wet granulation. *Construction and Building Materials,* Volume 157, pp. 573-581.

Noaman, A., Bakar, B. & Akil, H., 2015. The Effect of Combination between Crumb Rubber and Steel Fiber on Impact Energy of Concrete Beams. *Procedia Engineering,* Volume 125, pp. 825-831.

Randl, N. et al., 2014. Development of UHPC mixtures from an ecological point of view. *Construction and Building Materials,* Volume 67, pp. 373-378.

Rashid, M. & Mansur, M., 2009. Considerations in producing high strength concrete. *Journal of Civil Engineering (IEB),* 37(1), pp. 53-63 .

AbdelAleem, B. & Hassan, A., 2018. Development of self-consolidating rubberized concrete incorporating silica fume. *Construction and Building Materials,* Volume 161, pp. 389-397.

Ahn, Y., Jang, J. & Lee, H., 2016. Mechanical properties of lightweight concrete made with coal ashes after exposure to elevated temperatures. *Cement and Concrete Composites,* Volume 72, pp. 27-38.

Aiello, M. & Leuzzi, F., 2010. Waste tyre rubberized concrete: Properties at fresh and hardened state. *Waste Management,* 30(8-9), pp. 1696-1704.

Albayrak, G., Canbaz, M. & Albayrak, U., 2015. Statistical Analysis of Chemical Admixtures Usage for Concrete: A Survey of Eskisehir city, Turkey. *Procedia Engineering,* Volume 118, pp. 1236-1241.

Alsalman, A., Dang, C. & Hale, W., 2017. Evaluation of modulus of elasticity of ultra-high performance concrete. *Construction and Building Materials,* Volume 153, pp. 918-928.

Arafa, M., Shihada, S. & Karmout, M., 2010. Mechanical Properties of Ultra High Performance Concrete Produced in the Gaza Strip. *Asian Journal of Materials Science,* 2(1), pp. 1-12.

Azevedo, F. et al., 2012. Properties and durability of HPC with tyre rubber wastes. *Construction and Building Materials,* Volume 34, pp. 186-191.

Bisht, K. & Ramana, P., 2017. Evaluation of mechanical and durability properties of crumb rubber concrete. *Construction and Building Materials,* Volume 155, pp. 811-817.

de Reese, J., Lenz, P., Zilch, K. & Plank, J., 2013. Influence of type of superplasticizer and cement composition on the adhesive bonding between aged and fresh concrete. *Construction and Building Materials,* Volume 48, pp. 717-724.

Dumne, S., 2014. Effect of Superplasticizer on Fresh and Hardened Properties of Self-Compacting Concrete Containing Fly Ash. *American Journal of Engineering Research* , 3(3), pp. 205-211 .

Ferdosian, I. & Camões, A., 2017. Eco-efficient ultra-high performance concrete development by means of response surface methodology. *Cement and Concrete Composites,* Volume 84, pp. 146-156.

Ferreiro, S., Herfort, D. & Damtoft, J., 2017. Effect of raw clay type, fineness, water-to-cement ratio and fly ash addition on workability and strength performance of calcined clay – Limestone Portland cements. *Cement and Concrete Research,* Volume 101, pp. 1-12.

Gesoglu, M., Güneyisi, E., Nahhab, A. & Yazıcı, H., 2016. The effect of aggregates with high gypsum content on the performance of ultra-high strength concretes and Portland cement mortars. *Construction and Building Materials,* Volume 110, pp. 346-354.

Graybeal, B., 2011. Ultra-High Performance Concrete. *Federal Highway Administration Research and Technology,* Volume 40, pp. 202-493.

Graybeal, B. & Hartmann, J., 2003. Strength and Durability of Ultra-High Performance Concrete. *Federal Highway Administration.*

Guelmine, L., Hadjab, H. & Bennazouk, A., 2016. Effect of elevated temperatures on physical and mechanical properties of recycled rubber mortar. *Construction and Building Materials,* Volume 126, pp. 77-85.

Guneyisi, E., 2004. Properties of rubberized concretes containing silica fume. *Cement and Concrete Research.*

Guo, S. et al., 2017. Evaluation of properties and performance of rubber-modified concrete for recycling of waste scrap tire. *Journal of Cleaner Production,* Volume 148, pp. 681-689.

Guo, Y., Zhang, J., Chen, G. & Xie, Z., 2014. Compressive behaviour of concrete structures incorporating recycled concrete aggregates, rubber crumb and reinforced with steel fibre, subjected to elevated temperatures. *Journal of Cleaner Production,* Volume 72, pp. 193-203.

Gupta, T., Sharma, R. & Chaudhary, S., 2015. Impact resistance of concrete containing waste rubber fiber and silica fume. *International Journal of Impact Engineering,* Volume 83, pp. 76-87.

Gupta, T., Siddique, S., Sharma, R. & Chaudhary, S., 2017. ffect of elevated temperature and cooling regimes on mechanical and durability properties of concrete containing waste rubber fiber. *Construction and Building Materials,* Volume 137, pp. 35-45.

He, L., Ma, Y., Liu, Q. & Mu, Y., 2016. Surface modification of crumb rubber and its influence on the mechanical properties of rubber-cement concrete. *Construction and Building Materials,* Volume 120, pp. 403-407.

Hooton, R., Nehdi, M. & Khan, A., 2001. Cementitious Composites Containing Recycled Tire Rubber: An Overview of Engineering Properties and Potential Applications. *Cement, Concrete and Aggregates,* 23(1), p. 3.

Kim, G., Nam, I., Yoon, H. & Lee, H., 2018. Effect of superplasticizer type and siliceous materials on the dispersion of carbon nanotube in cementitious composites. *Composite Structures,* Volume 185, pp. 264-272.

Li, J., Saberian, M. & Nguyen, B., 2018. Effect of crumb rubber on the mechanical properties of crushed recycled pavement materials. *Journal of Environmental Management,* Volume 218, pp. 291-299.

Liu, J. et al., 2017. An overview on the effect of internal curing on shrinkage of high performance cement-based materials. *Construction and Building Materials,* Volume 146, pp. 702-712.

Mendis, A., Al-Deen, S. & Ashraf, M., 2017. Behaviour of similar strength crumbed rubber concrete (CRC) mixes with different mix proportions. *Construction and Building Materials,* Volume 137, pp. 354-366.

Mousa, M., 2017. Effect of elevated temperature on the properties of silica fume and recycled rubber-filled high strength concretes (RHSC). *HBRC Journal,* 13(1), pp. 1-7.

Onuaguluchi, O. & Panesar, D., 2014. Hardened properties of concrete mixtures containing pre-coated crumb rubber and silica fume. *Journal of Cleaner Production,* Volume 82, pp. 125-131.

Plank, J. et al., 2009. Effectiveness of Polycarboxylate Superplasticizers in Ultra-High Strength Concrete: The Importance of PCE Compatibility with Silica Fume. *Journal of Advanced Concrete Technology,* 7(1), pp. 5-12.

Rostami, M. & Behfarnia, K., 2017. The effect of silica fume on durability of alkali activated slag concrete. *Construction and Building Materials,* Volume 134, pp. 262-268.

Siddique, R., 2011. Utilization of silica fume in concrete: Review of hardened properties. *Resources, Conservation and Recycling,* 55(11), pp. 923-932.

Si, R., Guo, S. & Dai, Q., 2017. Durability performance of rubberized mortar and concrete with NaOH-Solution treated rubber particles. *Construction and Building Materials,* Volume 153, pp. 496-505.

Sofi, A., 2017. Effect of waste tyre rubber on mechanical and durability properties of concrete – A review. *Ain Shams Engineering Journal.*

Thomas, B. & Gupta, R., 2015. Long term behaviour of cement concrete containing discarded tire rubber. *Journal of Cleaner Production,* Volume 102, pp. 78-87.

Thomas, B. & Gupta, R., 2016. A comprehensive review on the applications of waste tire rubber in cement concrete. *Renewable and Sustainable Energy Reviews,* Volume 54, pp. 1323-1333.

Thomas, B., Gupta, R. & Panicker, V., 2016. Recycling of waste tire rubber as aggregate in concrete: durability-related performance. *Journal of Cleaner Production,* Volume 112, pp. 504-513.

Topcu, I. & Bilir, T., 2009. Experimental investigation of some fresh and hardened properties of rubberized self-compacting concrete. *Materials & Design,* 30(8), pp. 3056-3065.

Vítek, J., Coufal, R. & Čítek, D., 2013. UHPC – Development and Testing on Structural Elements. *Procedia Engineering,* Volume 65, pp. 218-223.

Wille, K. & Boisvert-Cotulio, C., 2015. Material efficiency in the design of ultra-high performance concrete. *Construction and Building Materials,* Volume 86, pp. 33-43.

Youssf, O., Mills, J. & Hassanli, R., 2016. Assessment of the mechanical performance of crumb rubber concrete. *Construction and Building Materials*, Volume 125, pp. 175-183.

Zhang, Z., Zhang, B. & Yan, P., 2016. Comparative study of effect of raw and densified silica fume in the paste, mortar and concrete. *Construction and Building Materials*, Volume 105, pp. 82-93.